DOCUMENT RESUME

ED 260 787 PS 015 243

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TITLE The Development of Anticipation in Solving Functional Composition Problems.
PUB DATE 6 Jun 85
NOTE 13p.; Paper presented at the Annual Symposium of the Jean Piaget Society (15th, Philadelphia, PA, June 6-8, 1985).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Age Differences; *Cognitive Ability; *Cognitive Development; Efficiency; Intuition; *Problem Solving; *Young Children
IDENTIFIERS *Anticipation; Developmental Patterns; *Function Concept; Piagetian Theory

ABSTRACT

Tasks based on the function concept ($y = f(x)$) were used in a study charting the development of anticipation in children from 5 through 7 years of age. In each task a desired outcome was a function of a combination of specific, rule-constrained, antecedent conditions. Subjects' behavior was scored according to criteria differentiating six levels of cognitive performance. Level 5 indicated consistent use of anticipation; Level 4 indicated partial use of anticipation, and Levels 3 through 0 referred to the use of trial-and-error strategies. Trial-and-error was defined as pausing to figure out what to do before each step in the solution, whereas anticipation was defined as pausing before the first step and then proceeding with the other steps without pause. Age trends in the data for these tasks indicated that (1) 5-year-olds generally find some solutions by trial-and-error; (2) 7-year-olds generally find most solutions by trial-and-error; and (3) solutions by operational anticipation become common only among 7-year-olds on the easiest task. Age trends for solutions termed "efficient," "repetitive," or "rambling" illustrated an "intuitive" form of anticipation in which trial-and-error behavior involved strategic searching at each step. Such intuitive anticipation was found to increase between 5 and 7 years of age. Correlations between functional composition ability and several concrete operational abilities support Piagetian theory. (RH)

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The Development of Anticipation in Solving Functional Composition Problems

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Presented at the Fifteenth

Annual Symposium of the Jean Piaget Society

June 6, 1985, Philadelphia

The Development of Anticipation in Solving Functional Composition Problems.

The use of anticipation in children's problem solving has often been cited as an index of the consolidation of cognitive structures. For example, beginning with Stage IV of the sensorimotor period infants manifest anticipation that a given action scheme can serve as a means to some further goal (e.g., Piaget, 1937/1954). This suggests that the set of available schemes is becoming linked together into a pragmatic system under some form of binary composition. One criterion of the emergence of formal operations is the ability to anticipate all logical combinations of propositions relating to a given problem. This form of anticipation has been taken as evidence for a system of operations on operations, referred to as the INRC group (Inhelder & Piaget, 1955/1958).

At the concrete operational level, we are familiar with the importance of anticipation in solving a variety of tasks, such as seriation of length and subdivision of area. In this paper I will describe a set of tasks based on the function concept (i.e., $y = f(x)$) that I've found to be helpful in charting the development of anticipation in children from 5 to 7 years of age. These tasks are derived from a problem Piaget and his collaborators used in their book on function concept development (Piaget, Grize, Szeminska, & Vinh-Bang, 1968/1977, chap. 1). As I will describe in the

discussion, solutions to these problems are particularly useful for clarifying a distinction between two types of anticipation, which I will refer to as "operational anticipation" and "intuitive anticipation."

Figure 1 shows the materials for one of the tasks. The task is presented as a game of trading little colored sticks for other little colored sticks. The materials include a board, about 16 inches long, which has 3 mounds representing little hills on it. Each hill has 3 holes representing tunnels. The other materials (not shown) are a set of twelve colored sticks (3 inch lengths of dowel) that can be pushed into the tunnels. The colored path leading to the entrance of each tunnel indicates which color stick is permitted to be pushed into that tunnel. The colored path at the exit of the tunnel indicates the color of the stick that will be pushed out. In other words the exit paths indicate the color of the sticks that are in the tunnels at the start of each game.

Insert Figure 1 about here

At the bottom of Figure 1 is shown the function that each mound represents: Mound g maps yellow to grey, green to yellow, and grey to green. After being instructed in the game rules corresponding to these functions, the children are presented with the

following type of problem: "Find where you can trade yellow for yellow." They naturally point to the middle mound. The interviewer continues, "But, what if the middle mound is closed for road repairs-- can you find another way to start with a yellow stick and end up with a different yellow stick?" This is a problem of functional composition. The children are being asked to compose 2 functions; for instance, by trading yellow for grey in mound a, then grey for yellow in mound b.

Two other tasks designed along similar lines were also used in the study; these materials are sketched in Figure 2. The messages task is presented as four school rooms, where each room has its own rule about who can talk to whom; the students in the school are described as belonging to four teams, designated by shirt color. For instance, in room a people in green shirts are only allowed to talk to people in blue shirts, and so on. A functional composition problem would be, for example, how to get a message from green to blue if room a is closed? The stores task is similar. There are four stores, and each one has its own rule that allows trading one kind of snack for another kind of snack. Thus store a permits trading crackers for gum. A problem might be, how to trade crackers for gum if store a is closed? (The flaps shown on both the messages game and the stores game are used to close the appropriate classroom or store during questioning.)

Insert Figure 2 about here

Figure 3 shows the criteria for scoring performance on these tasks. Notice that Level 5 refers to consistent use of anticipation, Level 4 refers to partial use of anticipation, and lower levels refer to trial-and-error strategies.

Insert Figure 3 about here

Trial-and-error is defined here as pausing to figure out what to do before each step in the solution. Anticipation is defined as pausing before the first step, then proceeding with the other steps without pause. I call this "operational anticipation" because the subject is mentally combining 2 functions to get a result that is also a member of the set of functions. That is, this is a closed binary operation defined on the set of functions.

Figure 4 shows the age trends for these tasks. The mean scores indicate that 5-year olds generally find some solutions, by trial-and-error. The 7-years olds generally find most solutions, usually by trial-and-error. Solutions by operational anticipation become common only among 7 years olds on the easiest task, the tunnels problem.

Insert Figure 4 about here

I also analyzed the data for "efficiency" of solutions. Efficient solutions are defined as those that require the least number of steps. For instance, in the tunnels task (see Figure 1), the solution of going from yellow to grey in mound a and then grey to yellow in mound b is the most efficient: it takes only two steps (i.e., one composition). Another solution would be to go from yellow to grey, then grey to green, and then green to yellow, all steps occurring within mound a. I term such solutions that require one extra step repetitive solutions. There are also a variety of other solutions, in which children make a long series of moves in a rambling way until they hit on the solution as if by accident.

Figure 5 shows the age trends for these three types of solutions. Notice that most of the efficient and repetitive solutions are not produced by the operational anticipatory strategy described above; this should be clear from the performance scores found in Figure 4. And clearly, rambling solutions are all by trial-and-error. (The reason so few rambling solutions appear in the graph is that most of them produce an incorrect outcome, and only correct solutions are included here. One interesting finding is that the intermediate age group produces most of the rambling

solutions: the younger kids use this strategy a lot, but can't complete a long series of moves successfully; older kids go directly to the more efficient solutions.)

Insert Figure 5 about here

These data on solution types help illustrate what I would call an intuitive form of anticipation: even though the kids in this study solve most of the problems without anticipating what the answer is, a majority of the kids do in fact anticipate that the problem has an answer of a particular form. This intuitive anticipation is seen in kids who search for the two-step solution, rather than one with more steps. These children guide their trial-and-error solutions by searching at each step for a solution, rather than just searching for a legal move.

Combining the data from Figures 4 and 5, we can say that children's use of intuitive anticipation increases between 5 and 7 years of age, and that there is evidence of operational anticipation by age 7.

To put these findings within a broader context, it is useful to recall how fundamental the function concept is in Piaget's theory. Using a structural analysis based on functions, he is able to link cognitive developments in infancy with subsequent developments through childhood and into adolescence (Piaget et al., 1968/

1977). The critical part of the theory, it seems to me, is the hypothesis that the thought of children from about 3 to 6 years of age is particularly characterizable in terms of developing function notions, and that these function notions pave the way for the binary operations of the concrete operational period.

The subjects in this research were participating in a larger study in which measures of concrete operations were administered; consequently, correlational evidence pertaining to Piaget's hypothesis is available. Figure 6 shows the degree of association between the functional composition ability described in this paper and several concrete operational abilities. The correlations are quite respectable. This adds support to Piaget's hypothesis, and indicates the potential fruitfulness of investigating further aspects of the development of function concepts.

Insert Figure 6 about here

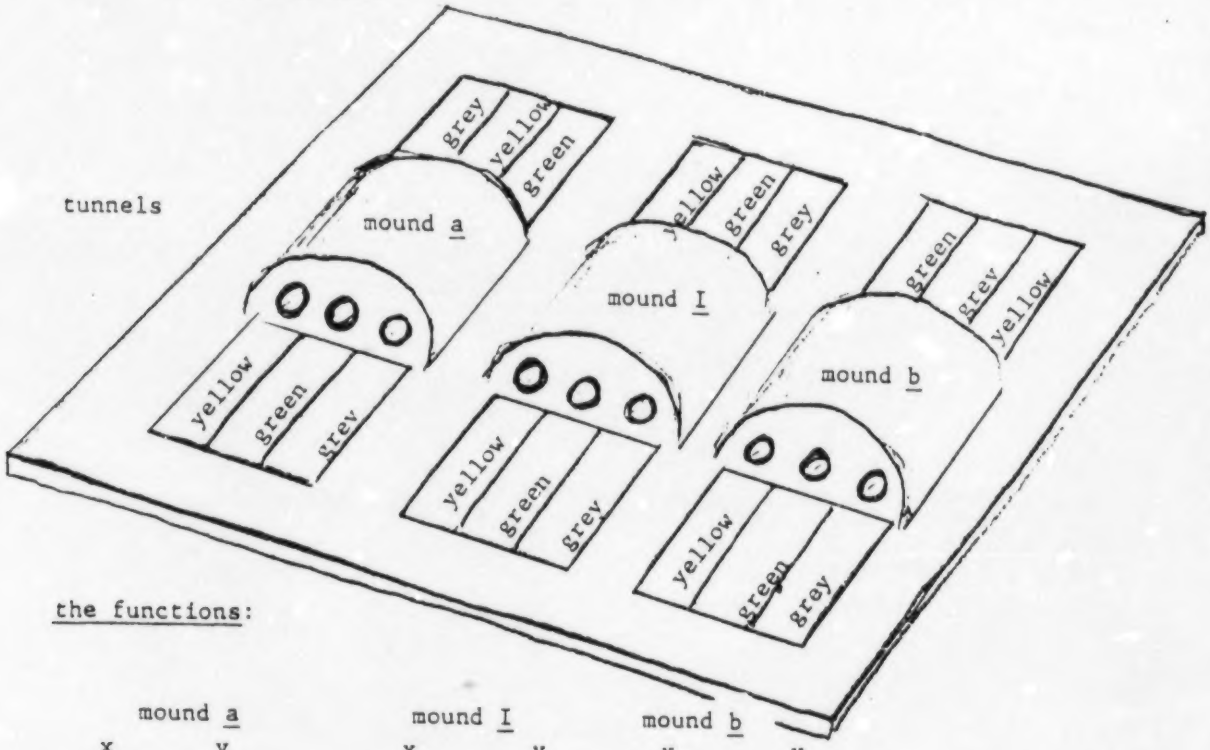
References

Inhelder, B. & Piaget, J. (1958). The growth of logical thinking from childhood to adolescence. New York: Basic Books. (Originally published, 1955)

Piaget, J. (1954). The construction of reality in the child. New York: Basic Books. (Originally published, 1937).

Piaget, J., Grize, J-B., Szeminska, A., & Vinh-Bang (1977). Epistemology and psychology of functions. Dordrecht, Holland: D. Reidel. (Originally published, 1968).

Figure 1. The tunnels game

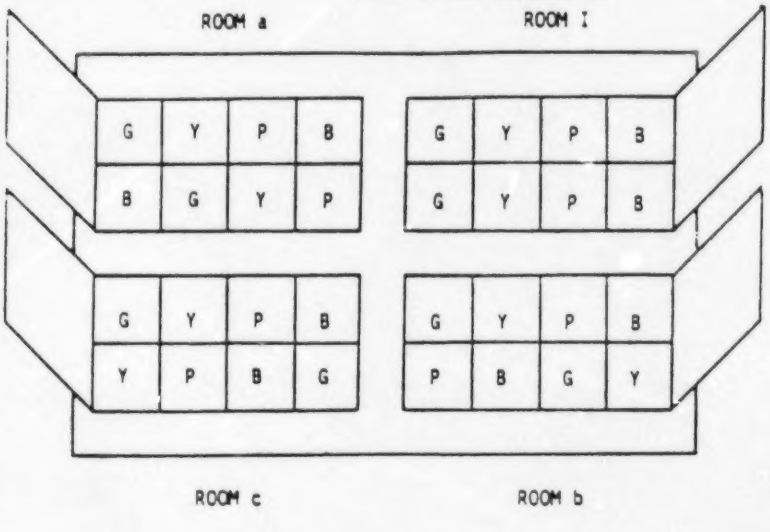


the functions:

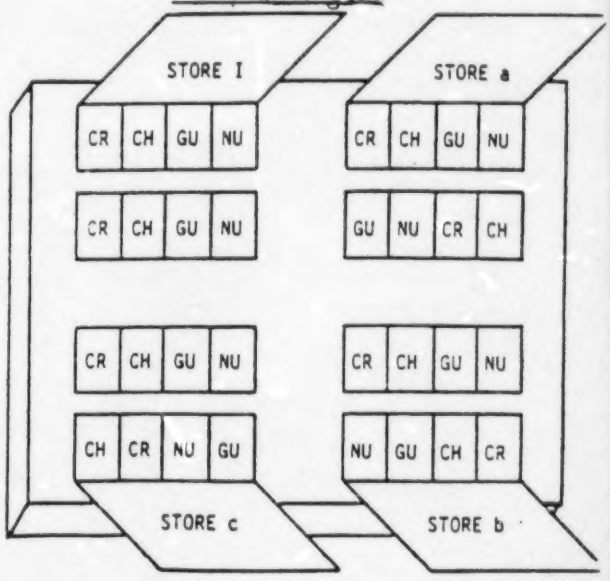
mound a		mound I		mound b	
x	y	x	y	x	y
yellow →	grey	yellow →	yellow	yellow →	green
green →	yellow	green →	green	green →	grey
grey →	green	grey →	grey	grey →	yellow

Figure 2.

The messages game



The stores game



G = GREEN SHIRTED FIGURE Y = YELLOW SHIRTED FIGURE

P = PINK SHIRTED FIGURE B = BLUE SHIRTED FIGURE

CR = CRACKERS CH = CHOCOLATES

GU = GUM NU = NUTS

Figure 3. Coding criteria

Level 0. No correct solutions.

Level 1. Finds a single solution to one problem.

Level 2. Finds a single solution to two problems; does not find both solutions for any problem.

Level 3. Finds both solutions to one problem. All solutions are found by trial-and-error; for example, requiring numerous prompts, repeating unnecessary exchanges, making disallowed exchanges before finding a correct sequence, etc.

Level 4. Finds correct solutions to all problems. Shows anticipatory strategy on at least one problem, but trial-and-error on remaining problems.

Level 5. Correct solutions to all problems, with anticipation; shows no evidence of trial-and-error.

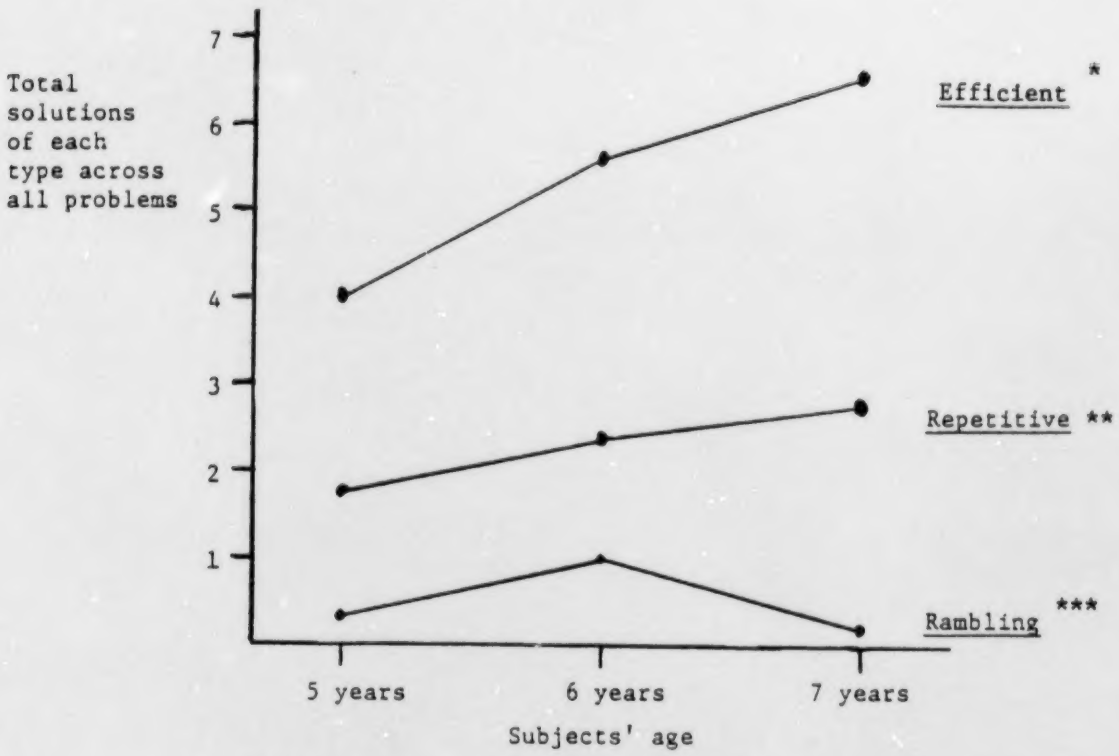
Note. Trial-and-error is defined as making a separate search for each step in the solution; that is, the subject pauses and searches prior to each exchange. Anticipation is defined as the absence of trial-and-error; that is, the subject pauses before the first exchange and then proceeds without pause through further exchanges.

Figure 4. Mean performance scores

	Age			Linear term	
	5	6	7	F(1,69)	P
Tunnels task	2.92	3.87	4.12	14.53	.001
Messages task	1.54	1.93	2.48	3.94	.05
Stores task	1.96	3.43	3.54	12.50	.001
Composite	2.14	3.08	3.38	14.52	.001

Note. The observed range of performance included both subjects who scored zero on all tasks and subjects who scored 5 on all tasks.

Figure 5. Mean solution type by age



*Linear term: $F(1, 69) = 15.32$, $p < .0002$
**Linear term: $F(1, 69) = 4.58$, $p < .04$
***Quadratic term: $F(1,69) = 8.44$, $p < .005$

Figure 6. Correlation of composite performance score with other cognitive abilities.

	Class inclusion	Seriation	Class vicariance	Number Conservation
Simple correlation	.57	.61	.62	.40
Controlling age	.51	.52	.55	.34

Note. All correlations significant at $p < .01$ or higher.